The development of civilization is in a sense a measure of man's success in providing himself with food. Early man devoted his primary effort in stalking and acquiring food. His successors developed the knowhow of domestication of plant and animal. The surpluses resulting from this organization relieved men and their talents for other purposes, from which evolved the arts, the religions, the sciences; the organizations of commerce, cities, nations, governments.

The development of civilization of man was not always easy. Wars, famine, pestilence, and revolutions are matters of recorded history. These were factors affecting and affected by food supplies. Major famines occurred in Europe very frequently after the year 1000; presumably, also before. Biblical record admonishes the use of systems of food storage against famine plague and pestilence.

Increase in production of food supplies followed major inventions of the times; the trace, the horse collar, the wheel, the team, the row, the hill, the plow, fallow, rotation, irrigation. Other developments have followed. Among these may be cited the pioneering of new land frontiers, mechanical and power developments for food production, improved techniques of food preservation and of its storage, improved understanding of the role of food in health, of biological knowledge and its application in plant and animal agriculture, and in educational systems for extending knowledge to producers of foods.

Through these means man has improved his health, his sufficiency, his pleasures and his numbers. Periodically, there have been threats, and jeopardy to this sequence of developments. Wars, famines, pestilence or plague do intervene. Malthus, in the 18th century, reasoned man could not keep up in providing the food needs for projected increases in population, and that the alternate to starvation would be plague, pestilence and war, thus rebalancing the food-man balance sheet.

It is evident that populations have increased since Malthus, and that food supplies in total have increased. But it is not so clear that Malthus was incorrect. For example, the estimates of the world population over the centuries are:

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1700</td>
<td>500 million</td>
</tr>
<tr>
<td>1850</td>
<td>1,000 million</td>
</tr>
<tr>
<td>1960</td>
<td>3,000 million</td>
</tr>
<tr>
<td>2000</td>
<td>6,000 million</td>
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</tbody>
</table>

But it is clear that while the population and the world food supply have increased, the availability of food in some parts of the world is wholly inadequate. Relatively few nations have food supplies, or economies that provide diets balanced or adequate in terms of the newer knowledge of nutrition. Many nations have inadequate supplies, and a great imbalance of dietary components. Both severe hunger, and severe malnutrition exist for many millions.

Thus, there is in the minds of men much concern about the abilities of the world to increase its food supply sufficiently to complement the current rapid rate of population increase.

It is believed that on the basis of current knowledge, world food supplies must be tripled by the turn of this century to meet population food and nutrition requirements.

Populations have increased because like begets like, obviously, but in perspective many factors have played a role in the zooming of the rate of population increase. Among these are:

1. A decline in mortality; historically, relatively few survived to maturity. Today, 90% survive to maturity.
2. The health of man has steadily increased because of the works of men like Hippocrates, Leeuwenhoek, Pasteur, Lister, Koch and their followers. Before 1920 there were plagues of cholera, smallpox, diphtheria, influenza. Since 1920 there have been no major pandemics.
3. There has been development of previously untouched and highly productive land frontiers in the Americas, Oceanic, Australia, and South Africa.
4. Transportation has improved from the camel and burro to air flight.
5. There has been tremendous application of power, from coal, fuel oil and water supply reserves.
6. There has been a fascinating revolution in agriculture, from Jethro Tull’s “Horse Hoeing Husbandry,” to applications of every facet of science in production of food plant and animal. It is recognized that the increase in productivity per man hour in agriculture has been greater than in other industries.

There are a number of potentialities that have been suggested for increasing the production, and
the efficiency of use of foods to minimize malnutrition, and to meet the requirements of the forthcoming doubling of population. Among them are:

1. Increasing tillable acreage by development of new lands—some 12.5 billion acres conceivably might be adapted—but this admittedly will be difficult to do.

2. Increase productivity of current operable land by irrigation; fertilization, agronomic developments, greater use of improved pesticides, improved livestock and livestock management practices, by fisheries developments, and so on. The production of many major crops in the United States (such as corn, hay, oats, vegetables, etc.) has doubled since 1933. But 827,000 tons daily of America's topsoil currently is lost at the outlet of the Mississippi River.

3. Shift agriculture from livestock to grain economy; it is estimated 94% of the world food supply is used directly as such, and that some 6% is derived indirectly from animals. In the U. S. some 35% of crop is fed through animals yielding one-third the available energy as food. It has been estimated that if this nation’s corn crop (4 billion bushel) were fed directly as human food, the energy would be sufficient for 250 million people; also, that by further intensified production, and efficiency in use of food, this country could feed 1,000 million people, but on much more restricted diets. However, animal agriculture does utilize efficiently forage crop not otherwise useful to men.

Increase in food production from available, or from contemplated new lands, requires a combination of conditions or qualities: favorable temperatures, adequately distributed water supplies, tolerable soils, properly balanced and available nutrients, and suitable topography. Scientifically developed plants and animals are highly sensitive to environmental conditions. Such combinations, in proper balance or distribution, are not easily achieved, and limit probabilities of frontier lands. Much of the increased production of food in the world is the result of intensification of agriculture on available lands.

Food, in the quantities and forms as we know it, is the result of a fascinating revolution in agriculture. In the U. S. one man provides enough food for twenty others, and the average outlay for food is only 20% of income. In Russia, one man provides enough for 7 others, and 50% or more of income for food is necessary. In other areas, virtually all work is expended for food, and in some, there is not enough food.

In the recent decade there has been much consolidation and enlargement of food production, food processing and distribution facilities. Marginal farms have been absorbed or abandoned; marginal processes have been replaced. The total number of farms operated in 1962 was about 2 million less than in 1950, present numbers are 3,688,000. It appears such consolidation and development will continue for a significant period. Current annual capital investments in food processing average 800 to 1,000 million dollars annually. From 1941 to 1961, the man-hour input required for production of foods decreased 14%, while product output increased 35%; the productivity per man-hour thus rose 56%.

Consumers spent $319 per person for food in 1947-49, and $392 in 1961, representing an increase in cash outlay of 23%. In the interim, disposable income increased 56%, from $1,248 to $1,937. The proportion of income spent for food declined from 25.6% in 1947-49 to 19.7% in 1961. It is estimated the quantity and type of foods purchased in 1935-39 would cost only 14.5% of current disposable income. Currently consumers fare better with much improved foods, at relatively less cost.

Thus, we must examine not only the developments which have enabled the modern foods, but consider potentials and problems of the future. Foods processing, the conversion of raw inedible forms of food into something edible and useful at another time and place, has undergone tremendous change in recent years. Some 10,000 food plants employ every conceivable form of engineered operation for the processing of foods. There has been both reduction in the numbers of plants, and increase in their size. There has been installation of automation and precision controls for the multitudes of treatments. It has been suggested shortly some 90% of the nation’s poultry requirements could be produced on 50 commercial poultry farms; that in each of coadjacent selected plants process rates of 10,000 birds or 27,000 pounds ready to cook poultry per hour are feasible. Bird ranches already are in operation handling 200,000-500,000 birds continuously. The application of the processes, the efficiency required for their operation, requires large investments and large volume operation and distribution. Thus, most certainly we can look forward to greater intensification in agriculture, and fewer plants geared to larger scale engineered operations for foods.

Increased crop production economically justified and enabled control of predatory insects, diseases and weeds. Uncontrolled, such pests could destroy 30-50% of the total food crop. DDT was followed by chlorinated hydrocarbons, organic phosphates and systemic insecticides. Disease control was improved by compounds such as the organic mercury, dithiocarbamate fungicides; weeds have been suppressed by 2,4-D and other phenoxyacetic derivatives, and substituted urea compounds. Increased animal production has been obtained by use of feed ration supplements of urea, methionine, antibiotics, and vitamins. Animal diseases have been much suppressed by a host of veterinary drugs and by chemi-
cally modified sanitation practices. The storage carry over of foods has been improved by diverse processes: controls of temperature and gas conditions, treatments with spoilage inhibitors, and improved means of protection against insect and rodent damage.

The efficient and low cost production of foods of the future will involve increased use of balanced feeds, with additives and supplements which increase gain/feed ratios and minimize costs of handling. Application of Mendelian principles has up-graded quality and potentials of meat, vegetable, and fruit lines. Management and housing have made significant differences in animal population increase rates, and weight gains. Utilization of genetic principles has enabled development of disease resistant strains of many crops, with nutritive qualities, processing qualities, and improved yields. Early application of low cost soil nutrients, principally nitrogen, following Hafer's work on N fixation, and subsequent use of nitrates, ammonia, and deposit sources of mineral fertilizers, has been important in sustaining yields from various soils.

Thus, the geographic and climatic advantages in America of climate, soil, distributed rainfall, transportation, technology and agricultural education have been important in our population/food ratios. The rapidly expanding fund of knowledge by which more, and better foods can be produced, and which must be produced, is essential. The average American eats 4.66 pounds food per day; the average Indian across the world consumes 1.23 pounds per day.

Food supplies are of world-wide, as well as national origin. Many organizations deal extensively with raw food, and processed food components from distant places. Few individuals consume a meal without some imported component. Significant too, is the utilization of specially processed functional ingredients or components of foods. These have special built in qualities which enable controlled uniform processing of foods; in many instances they are essential to bioengineered foods operations. Examples are modified fats or oils, flours, starches, sweeteners, eggs, milks. It includes functional items such as emulsifiers, stabilizers, leaveners, enzymes, bleaching and curing agents, acidulants and so on. Literally thousands of products and blends have been developed for improved food operations, and foods. Unquestionably the development of improved functional ingredients will continue, since they are essential. There are inherent problems in their use which must be faced in the future: the effects of multiprocessing, multihandling, and widespread, as well as large-scale utilization imply potential health hazards.

The decrease in numbers, and the increase in size of food plant operations have involved water, and waste problems. Land water tables have dropped seriously in many areas, requiring deeper pumping, and transported waters. Water supplies are often derived from vast drainage areas, where waste and water come mingle. Such waters, when purified, are potable, but frequently unsatisfactory for food process operations. They require further purification. Food operations require 300-15,000 gallons water per ton of raw material; line flow capacities often scale 10-50 ton of food per hour.

Larger food plants generate large waste disposal problems. Output waste may range from 10-70% of input of raw material in the plant. New systems of land sprays, and lagooning have been developed to meet this problem. In all probability, the problems of water and waste for food processing will become more serious, with the increase in population and pressure for foods.

The early American diet of bread, meat, and potatoes has given way to a new system of foods. The winter larder of the cellar, so aptly described by Herbert Hoover, has given way to but a few days supply in the modern kitchen. Over 30% of all married women are employed for wages. About 25% of all food produced is consumed in institutional operations. The average American eats one meal away from home, daily. Some component of his meal, if not several, has come from a distant place, and has been stored for a period of time, and has been multiprocessed. Modern food must have convenience of form, shape, package, use or preparation. The average supermarket holds some 6-8,000 items, with 100 new ones daily being offered for place on the shelves. There currently is tremendous increase in hot/cold vending systems, industrial and social feeding or catering systems. These are in part the result of changing concepts of the social systems of man. Continued change may be anticipated for the future. American man has abandoned the cracker barrel, the pickle barrel, the flour barrel, the potato bin, the butter crock, the cheese wheel for convenience, variety, reduced spoilage, better nutrition, at less cost.

There has been a noticeable lag in the development of sanitary standards in many foods industries, in comparison with those in the past decade in the dairy industry. This has been due, possibly to three causes: a) the want of a satisfactory yardstick with which to make acceptance valuations; b) the great diversity of type and of origin of materials in foods; and c) the continuing process of invention. While great strides have been made in concepts of sanitary design of equipment, as for dairy, bakery and certain restaurant facilities, and in certain sanitary survey codes, as for milk, restaurant, shell fish, much remains to be done in other segments of the food industry. The understanding of the profit advan-
tages of aesthetic as well as protective and preventative sanitation in modern food production of the future probably will become widespread because competition will require it. Automation will be an essential part of these operations. These plants will require managers with advanced technical training. The operations will be controlled and monitored by continuously operating automatic analyzing techniques.

The continued intensification of production, processing and distribution of foods in the forthcoming America of a doubled population brings light on the current archaic inadequacy in the monitoring of food borne illness. Real impact of contaminated food cannot now be properly evaluated. Few individuals escape occasional intestinal upset; the migrant habits of a large percentage of the population make tracing of significant, but dispersed, outbreaks difficult. In spite of apparent improvement in process and handling techniques, the number of food borne epidemics has at least doubled in the past 10 years. There is great need for, and there probably will become available, but only with great effort, comparative data on the microbiological, chemical, nutritional, toxicological and related qualities of principal food items. There probably will be perfection and application of systems of surveillance through statistical sampling and monitoring equipment. There probably will be greater reliance on monitored attributes, and less on aesthetic minutiae.

It is difficult to contemplate the nature of foods of the future. Currently modern foods embody principles of process and preservation known long ago: salting, heating, smoking, drying, freezing, fermenting, concentrating. Modern foods simply embody refinements, and control of these procedures.

There undoubtedly will be intensification of agriculture for more food, with understanding and control of calculated hazards of adjuncts. In all probability, the production of more food, even on the best of land, will require greater use of machinery, fertilizer, soil fumigants, pesticides and related treatments. Most certainly there will be needed greater security against disastrous crop failures. There undoubtedly will be new systems of preservation of foods by chemicals, antibiotics and by physical means. There will be extensive use of adjuncts in process and distribution of foods, in order to reduce costs. There will be synthesis of foods, biological and chemical. There will be pressures toward cereals and fisheries type foods.

Perhaps we shall ultimately follow the predictions of Edward Bellamy, made in 1890 in his book "Looking Backwards 2000 Years," in which he depicts community production and utilization of foods in a different way of life.

Sir William Slater has pointed to the world's dilemma: "that having found the means of overcoming early death, it must take steps to prevent the creation of life in excess of that for which food can be provided. Both the limitation of reproduction and the expansion of food production are hedged around with beliefs and prejudices, religious and emotional, which have to be overcome." The foods of the future will depend upon our understanding of these factors.

REFERENCES